South Downs Mercury

The monthly circular of South Downs Astronomical Society
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Main Talk William Joyce **"Astrobiology."** With an astrophysics degree, William has worked in space research at Leicester university with Earth remote sensing satellite instruments and in industry in laboratories, space software engineering and later in aerospace systems engineering. William changed career in the mid 2000's and obtained a degree in Earth and Planetary science and followed this with university teaching and astronomy work

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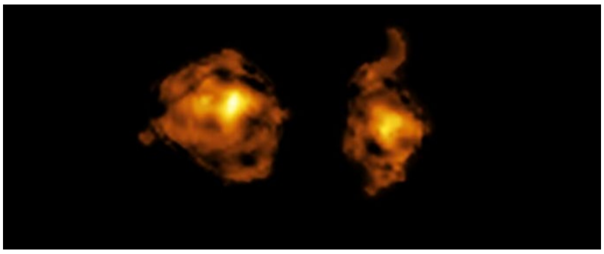
- 'Cosmic joust': Astronomers observe pair of galaxies in deep-space battle

Date: May 21, 2025
Source: ESO



Astronomers have witnessed for the first time a violent cosmic collision in which one galaxy pierces another with intense radiation. Their results, published today in Nature, show that this radiation dampens the wounded galaxy's

Astronomers have witnessed for the first time a violent cosmic collision in which one galaxy pierces another with intense radiation. Their results, published today in *Nature*, show that this radiation dampens the wounded galaxy's ability to form new stars. This new study combined observations from both the European Southern Observatory's Very Large Telescope (ESO's VLT) and the Atacama Large Millimetre/submillimetre Array (ALMA), revealing all the gory details of this galactic battle.

In the distant depths of the Universe, two galaxies are locked in a thrilling war. Over and over, they charge towards each other at speeds of 500 km/s on a violent collision course, only to land a glancing blow before retreating and winding up for another round. "*We hence call this system the 'cosmic joust'*," says study co-lead Pasquier Noterdaeme, a researcher at the Institut d'Astrophysique de Paris, France, and the French-Chilean Laboratory for Astronomy in Chile, drawing a comparison to the medieval sport. But these galactic knights aren't exactly chivalrous, and one has a very unfair advantage: it uses a quasar to pierce its opponent with a spear of radiation.

Quasars are the bright cores of some distant galaxies that are powered by supermassive black holes, releasing huge amounts of radiation. Both quasars and galaxy mergers used to be far more common, appearing more frequently in the Universe's first few billion years, so to observe them astronomers peer into the distant past with powerful telescopes. The light from this 'cosmic joust' has taken over 11 billion years to reach us, so we see it as it was when the Universe was only 18% of its current age.

"Here we see for the first time the effect of a quasar's radiation directly on the internal structure of the gas in an otherwise regular galaxy," explains study co-lead Sergei Balashev, who is a researcher at the Ioffe Institute in St Petersburg, Russia. The new observations indicate that radiation released by the quasar disrupts the clouds of gas and dust in the regular galaxy, leaving only the smallest, densest regions behind. These regions are likely too small to be capable of star formation, leaving the wounded galaxy with fewer stellar nurseries in a dramatic transformation.

But this galactic victim isn't all that is being transformed. Balashev explains: "These mergers are thought to bring huge amounts of gas to supermassive black holes residing in galaxy centres." In the cosmic joust, new reserves of fuel are brought within reach of the black hole powering the quasar. As the black hole feeds, the quasar can continue its damaging attack.

This study was conducted using ALMA and the X-shooter instrument on ESO's VLT, both located in Chile's Atacama Desert. ALMA's

high resolution helped the astronomers clearly distinguish the two merging galaxies, which are so close together they looked like a single object in previous observations. With X-shooter, researchers analysed the quasar's light as it passed through the regular galaxy. This allowed the team to study how this galaxy suffered from the quasar's radiation in this cosmic fight.
Observations with larger, more powerful telescopes could reveal more about collisions like this. As Noterdaeme says, a telescope like ESO's Extremely Large Telescope "will certainly allow us to push forward a deeper study of this, and other systems, to better understand the evolution of quasars and their effect on host and nearby galaxies."

- Astronomers observe largest ever sample of galaxies up to over 12 billion light years away

Date: May 19, 2025

Source: Aalto University

(Credit ESA/WEBB, NASA & CSA, G. Gozaliasl, A. Koekemoer, M. Franco, and the COSMOS Web team).

The largest sample of galaxy groups ever detected has been presented by a team of international astronomers using data from the James Webb Space telescope (JWST) in an area of the sky called COSMOS Web. The study marks a major milestone in extragalactic astronomy, providing unprecedented insights into the formation and evolution of galaxies and the large-scale structure of the universe. Peering back in time to when the universe was younger than the Earth is now, the images span the period from around twelve billion years ago until one billion years ago. The new catalogue of images, soon to be published in the journal *Astronomy and Astrophysics* (*A&A*), includes nearly 1,700 galaxy groups. The research group's impressive image of a galaxy cluster over 6 billion light years away is currently showcased as the European Space Agency's (ESA) picture of the month.
'We're able to actually observe some of the first galaxies formed in the universe,' says Ghassem Gozaliasl of Aalto University, and head of the galaxy groups detection team who led the study. 'We detected 1,678 galaxy groups or proto-clusters -- the largest and deepest sample of galaxy groups ever detected -- with the James Webb Space telescope. With this sample, we can study the evolution of galaxies in groups over the past 12 billion years of cosmic time.'
The James Webb Space Telescope began operating in 2022. The largest telescope in space, its higher resolution and greater sensitivity have enabled astronomers to see farther and better than ever before. Because light travels at a finite speed, the further away an object is, the further back in time our image of it. By observing very faint, very distant galaxies -- the faintest galaxies in this dataset are one billion times dimmer than the human eye can see -- the team got a glimpse of what galaxies looked like in the early universe.
Galaxy groups and clusters are rich environments filled with dark matter, hot gas, and massive central galaxies that often host supermassive black holes, explains Gozaliasl. 'The complex interactions between these components play a crucial role in shaping the life cycles of galaxies and driving the evolution of the groups and clusters themselves. By uncovering a more complete history of these cosmic structures, we can better understand how these processes have influenced the formation and growth of both massive galaxies and the largest structures in the universe.'

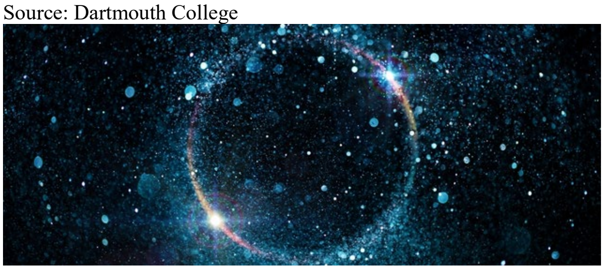
Cosmic family history

Galaxies aren't scattered evenly throughout the universe. Instead, they cluster in dense regions connected by filaments and walls, forming a vast structure known as the cosmic web. Truly isolated galaxies are rare -- most reside in galaxy groups, which typically contain anywhere from three to a few dozen galaxies, or in larger galaxy clusters, which can include hundreds or even thousands of galaxies bound together by gravity. Our own Milky Way is part of a small galaxy group known as the Local Group, which includes the Andromeda Galaxy and dozens of smaller galaxies.

'Like humans, galaxies come together and make families,' explains Gozaliasl. 'Groups and clusters are really important, because within them galaxies can interact and merge together, resulting in the transformation of galaxy structure and morphology. Studying these environments also helps us understand the role of dark matter, feedback from supermassive black holes, and the thermal history of the hot gas that fills the space between galaxies.'
Because the new catalogue includes observations that span from one billion to twelve billion years ago, scientists can compare some of the earliest structures in the universe with relatively modern ones to learn more about galaxy groups and how they evolve. Studying the history of galaxy groups can also help astronomers understand how the giant, brightest group galaxies (BGGs) at their centres form through repeated mergers -- an area explored in depth across several of Gozaliasl's recent publications.
'When we look very deep into the universe, the galaxies have more irregular shapes and are forming many stars. Closer to our time, star formation is what we refer to as 'quenched' -- the galaxies have more symmetric structures, like elliptical or spiral galaxies. It's really exciting to see the shapes changing over cosmic time. We can start to address so many questions about what happened in the universe and how galaxies evolved,' says Gozaliasl.

- ❖ Dark matter formed when fast particles slowed down and got heavy, new theory says

Date: May 14, 2025
Source: Dartmouth College



(RomoloTavani/Getty Images)

A study by Dartmouth researchers proposes a new theory about the origin of dark matter, the mysterious and invisible substance thought to give the universe its shape and structure.
The researchers report in *Physical Review Letters* that dark matter could have formed in the early life of the universe from the collision of high-energy massless particles that lost their zip and took on an incredible amount of mass immediately after pairing up, according to their mathematical models.
While hypothetical, dark matter is believed to exist based on observed gravitational effects that cannot be explained by visible matter. Scientists estimate that 85% of the universe's total mass is dark matter.
But the study authors write that their theory is distinct because it can be tested using existing observational data. The extremely low-energy particles they suggest make up dark matter would have a unique signature on the Cosmic Microwave Background, or CMB, the leftover radiation from the Big Bang that fills all of the universe.
"Dark matter started its life as near-massless relativistic particles, almost like light," says Robert Caldwell, a professor of physics and astronomy and the paper's senior author. "That's totally antithetical to what dark matter is thought to be -- it is cold lumps that give galaxies their mass," Caldwell says. "Our theory tries to explain how it went from being light to being lumps."
Hot, fast-moving particles dominated the cosmos after the burst of energy known as the Big Bang that scientists believe triggered the universe's expansion 13.7 billion years ago. These particles were similar to photons, the massless particles that are the basic energy, or quanta, of light.
It was in this chaos that extremely large numbers of these particles bonded to each other, according to Caldwell and Guanming Liang, the study's first author and a Dartmouth senior.
They theorize that these massless particles were pulled together by the opposing directions of their spin, like the attraction between the north and south poles of magnets. As the particles cooled, Caldwell and Liang say, an imbalance in the particles' spins caused their energy to plummet, like steam rapidly cooling into water. The outcome was the cold, heavy particles that scientists think constitute dark matter.
"The most unexpected part of our mathematical model was the energy plummet that bridges the high-density energy and the lumpy low energy," Liang says.
"At that stage, it's like these pairs were getting ready to become dark matter," Caldwell says. "This phase transition helps explain the abundance of dark matter we can detect today. It sprang from the high-density cluster of

extremely energetic particles that was the early universe."

The study introduces a theoretical particle that would have initiated the transition to dark matter. But scientists already know that the subatomic particles known as electrons can undergo a similar transition, Caldwell and Liang say.

At low temperatures, two electrons can form what are known as Cooper pairs that can conduct electricity without resistance and are the active mechanism in certain superconductors. Caldwell and Liang cite the existence of Cooper pairs as evidence that the massless particles in their theory would have been capable of condensing into dark matter.

"We looked toward superconductivity for clues as to whether a certain interaction could cause energy to drop so suddenly," Caldwell says. "Cooper pairs prove that the mechanism exists."

The metamorphosis of these particles from the cosmic equivalent of a double espresso into day-old oatmeal explains the vast deficit in the energy density of the current universe compared to its early days, Liang says. Scientists know that density has declined since the Big Bang as the universe's energy expands outward. But Liang and Caldwell's theory also accounts for the increase in the density of mass.

"Structures get their mass due to the density of cold dark matter, but there also has to be a mechanism wherein energy density drops to close to what we see today," Liang says.

"The mathematical model of our theory is really beautiful because it's rather simplistic -- you don't need to build a lot of things into the system for it to work," he says. "It builds on concepts and timelines we know exist."

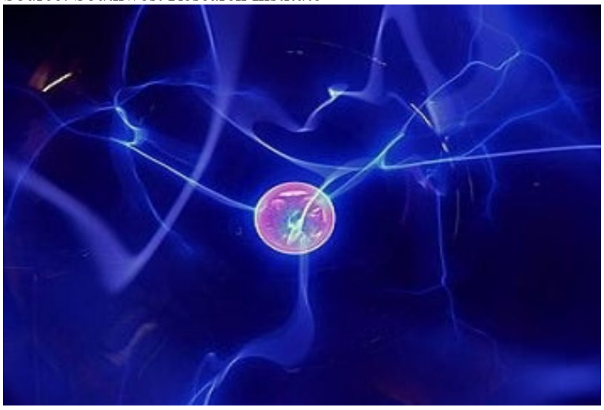
Their theory suggests that the particle pairs entered a cold, nearly pressureless state as they got slower and heavier. This characteristic would make them stand out on the CMB. The CMB has been studied by several large-scale observational projects and is the current focus of the Simons Observatory in Chile and other experiments such as CMB Stage 4.

Existing and future data from these projects could be used to test Caldwell and Liang's theory, the researchers say.

"It's exciting," Caldwell says. "We're presenting a new approach to thinking about and possibly identifying dark matter."

- Scientist discovers how solar events affect the velocity of helium pickup ions

Date: May 21, 2025
Source: Southwest Research Institute



Southwest Research Institute scientists have discovered how solar activity affects the velocity distribution and evolution of helium pickup ions.

Pickup ions are charged particles created when neutral particles originating outside of our solar system are ionized. They are ionized by solar ultraviolet radiation and captured by the interplanetary magnetic field.

A new study led by SwRI's Dr. Keiichi Ogasawara indicates that these pickup ions are a wellspring of solar energetic particles (SEPs). These high-energy accelerated particles include protons, electrons and heavy ions produced by solar events like flares and coronal mass ejections (CMEs). Using data from NASA's Solar TErrestrial RElations Observatory, SwRI detected the initial characteristics of the helium pickup ion acceleration through several CME events.

"We carefully identified the specific properties of the ions and used them to trace the physical energy transfer processes," Ogasawara said. "We also considered the roles played by different types of interplanetary shocks, when fast-moving solar wind disturbances collide with slower-moving solar wind plasmas."

Understanding how and when SEPs occur is critical because, when they are accelerated to higher energies, they can penetrate spacecraft and spacesuits, posing a radiation hazard to astronauts.

SwRI also studied the velocities of individual helium pickup ions in relation to their local magnetic field orientations and identified their characteristic behaviours when interacting with different types of shocks associated with CMEs.

"The velocity distribution of pickup ions is quite different from that of the solar wind," Ogasawara said. "In fact, they can be twice as fast as the solar wind even during relatively quiet times. Because of this difference, pickup ions are more effectively accelerated to even higher energies than normal solar wind particles.

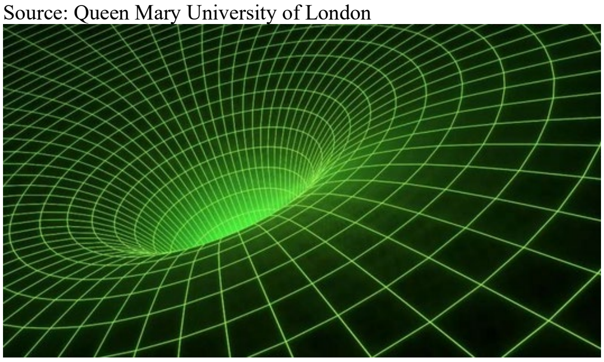
In comparison to SEPs, the solar wind is a continuous lower-energy flow of plasma emitted by the corona, the Sun's outer atmosphere.

SwRI developed a new method for tracking particle evolution as pickup ions travel through shock passages, turbulence and large-scale magnetic structures. This allows researchers to separate processes that increase or decrease energy from those that maintain energy levels.

"This study examined particle behaviour across a broad range of structures in the heliosphere including magnetic structures, interplanetary shocks and the sheath region that forms in advance of a CME," Ogasawara said.

- New insights into black hole scattering and gravitational waves unveiled

Date: May 14, 2025
Source: Queen Mary University of London



Credit: CC0 Public Domain

A landmark study published in Nature has established a new benchmark in modelling the universe's most extreme events: the collisions of black holes and neutron stars. This research, led by Professor Jan Plefka at Humboldt University of Berlin and Queen Mary University London's Dr Gustav Mogull, formerly at Humboldt Universität and the Max Planck Institute for Gravitational Physics (Albert Einstein Institute), and conducted in collaboration with an international team of physicists, provides unprecedented precision in calculations crucial to understanding gravitational waves.

Using cutting-edge techniques inspired by quantum field theory, the team calculated the fifth post-Minkowskian (5PM) order for observables such as scattering angles, radiated energy, and recoil. A groundbreaking aspect of the work is the appearance of Calabi-Yau three-fold periods -- geometric structures rooted in string theory and algebraic geometry -- within the radiative energy and recoil. These structures, once considered purely mathematical, now find relevance in describing real-world astrophysical phenomena.

With gravitational wave observatories like LIGO entering a new phase of sensitivity and next-generation detectors such as LISA on the horizon, this research meets the increasing demand for theoretical models of extraordinary accuracy.

Dr Mogull explained the significance: "While the physical process of two black holes interacting and scattering via gravity we're studying is conceptually simple the level of mathematical and computational precision required is immense."

Benjamin Sauer, PhD candidate at Humboldt University of Berlin adds: "The appearance of Calabi-Yau geometries deepens our understanding of the interplay between mathematics and physics. These insights will shape the future of gravitational wave astronomy by improving the templates we use to interpret observational data."

This precision is particularly important for capturing signals from elliptic bound systems, where orbits more closely resemble high-velocity scattering events, a domain where traditional assumptions about slow-moving black holes no longer apply.

Gravitational waves, ripples in spacetime caused by accelerating massive objects, have revolutionised astrophysics since their first detection in 2015. The ability to model these waves with precision enhances our understanding of cosmic phenomena, including the "kick" or recoil of black holes after scattering -- a process with far-reaching implications for galaxy formation and evolution.

Perhaps most tantalisingly, the discovery of Calabi-Yau structures in this context connects the macroscopic realm of astrophysics with the intricate mathematics of quantum mechanics. "This could fundamentally change how physicists approach these functions," said team member Dr Uhre Jakobsen of Max Planck Institute for Gravitational Physics and Humboldt University of Berlin. "By demonstrating their physical relevance, we can focus on specific examples that illuminate genuine processes in nature."

The project utilised over 300,000 core hours of high-performance computing at the Zuse Institute Berlin to solve the equations governing black hole interactions, demonstrating the indispensable role of computational physics in modern science. "The swift availability of these computing resources was key to the success of the project," adds PhD candidate Mathias Driesse, who led the computing efforts.

Professor Plefka emphasised the collaborative nature of the work: "This breakthrough highlights how interdisciplinary efforts can overcome challenges once deemed insurmountable. From mathematical theory to practical computation, this research exemplifies the synergy needed to push the boundaries of human knowledge."

This breakthrough not only advances the field of gravitational wave physics but also bridges the gap between abstract mathematics and the observable universe, paving the way for discoveries yet to come. The collaboration is set to expand its efforts further, exploring higher-order calculations and utilising the new results in future gravitational waveform models. Beyond theoretical physics, the computational tools used in this study, such as KIRA, also have applications in fields like collider physics.

This achievement was the result of extensive international collaboration and advanced mathematical and computational methods.

The groundwork for the study was laid in Plefka's group at Humboldt University of Berlin, where the Worldline Quantum Field Theory formalism was pioneered together with Dr Gustav Mogull. Over time, the collaboration expanded to include world-leading specialists such as Dr Johann Usovitsch, who moved from CERN to Humboldt University of Berlin and is the developer of the KIRA software, as well as mathematical physicists Dr Christoph Nega (Technical University of Munich) and Professor Albrecht Klemm (University of Bonn), leading experts on Calabi-Yau manifolds.

The project received key funding through Professor Plefka's ERC Advanced Grant GraWFTy, the RTG 2575 Rethinking Quantum Field Theory, and the novel Research Unit FOR 5582 of the Deutsche Forschungsgemeinschaft, in which Plefka and Klemm are principal investigators. It was also supported by Dr Mogull's Royal Society University Research Fellowship, Gravitational Waves from Worldline Quantum Field Theory.

- Saturn's moon: Mysterious wobbling atmosphere like a gyroscope

Date: May 22, 2025
Source: University of Bristol

This view of Titan is among the last images NASA’s Cassini spacecraft sent to Earth before it plunged into the giant planet’s atmosphere. Image credit: NASA / JPL-Caltech / Space Science Institute.

The puzzling behaviour of Titan's atmosphere has been revealed by researchers at the University of Bristol for the first time.

By analysing data from the Cassini-Huygens mission, a joint venture between NASA, the European Space Agency (ESA), and the Italian Space Agency, the team have shown that the thick, hazy atmosphere of Saturn's largest moon doesn't spin in line with its surface, but instead wobbles like a gyroscope, shifting with the seasons.

Titan is the only moon in the Solar System with a significant atmosphere, and one that has long captivated planetary scientists. Now, after 13 years of thermal infrared observations from Cassini, researchers have tracked how Titan's atmosphere tilts and shifts over time.

"The behaviour of Titan's atmospheric tilt is very strange!" said Lucy Wright, lead author and postdoctoral researcher at Bristol's School of Earth Sciences. "Titan's atmosphere appears to be acting like a gyroscope, stabilising itself in space.

"We think some event in the past may have knocked the atmosphere off its spin axis, causing it to wobble.

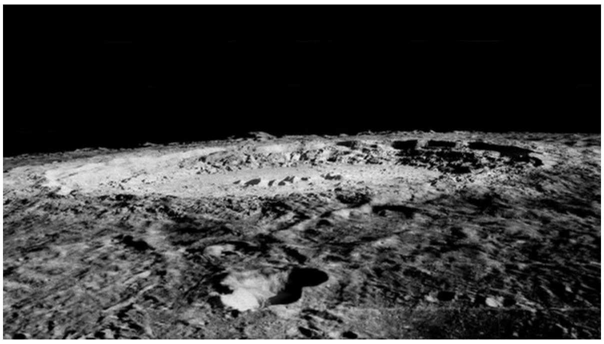
"Even more intriguingly, we've found that the size of this tilt changes with Titan's seasons."

The team studied the symmetry of Titan's atmospheric temperature field and found that

it isn't centred exactly on the pole, as expected. Instead, it shifts over time, in step with Titan's long seasonal cycle -- each year on Titan lasts nearly 30 years on Earth.
Professor Nick Teanby, co-author and planetary scientist at Bristol said: "What's puzzling is how the tilt direction remains fixed in space, rather than being influenced by the Sun or Saturn.
"That would've given us clues to the cause. Instead, we've got a new mystery on our hands."
This discovery will impact NASA's upcoming Dragonfly mission, a drone-like rotorcraft scheduled to arrive at Titan in the 2030s. As Dragonfly descends through the atmosphere, it will be carried by Titan's fast-moving winds -- winds that are about 20 times faster than the rotation of the surface.
Understanding how the atmosphere wobbles with the seasons is crucial for calculating the landing trajectory of Dragonfly. The tilt affects how the payload will be carried through the air, so this research can help engineers better predict where it will touch down.
Dr Conor Nixon, planetary scientist at NASA Goddard and co-author of the study, added: "Our work shows that there are still remarkable discoveries to be made in Cassini's archive.
"This instrument, partly built in the UK, journeyed across the Solar System and continues to give us valuable scientific returns.
"The fact that Titan's atmosphere behaves like a spinning top disconnected from its surface raises fascinating questions -- not just for Titan, but for understanding atmospheric physics more broadly, including on Earth."
The team's findings contribute to a growing body of research suggesting Titan is not just Earth-like in appearance but an alien world with climate systems all its own, and many secrets still hidden beneath its golden haze

- ❖ Why are some rocks on the moon highly magnetic?

A large impact could have briefly amplified the moon's weak magnetic field, creating a momentary spike that was recorded in some lunar rocks
Date: May 23, 2025
Source: Massachusetts Institute of Technology



The Mare Imbrium Basin, on the northern nearside of the moon. (Image credit: NASA/JPL/USGS)

Where did the moon's magnetism go? Scientists have puzzled over this question for decades, ever since orbiting spacecraft picked up signs of a high magnetic field in lunar surface rocks. The moon itself has no inherent magnetism today.
Now, MIT scientists may have solved the mystery. They propose that a combination of an ancient, weak magnetic field and a large, plasma-generating impact may have temporarily created a strong magnetic field, concentrated on the far side of the moon.
In a study appearing in the journal *Science Advances*, the researchers show through detailed simulations that an impact, such as from a large asteroid, could have generated a cloud of ionized particles that briefly enveloped the moon. This plasma would have streamed around the moon and concentrated at the opposite location from the initial impact. There, the plasma would have interacted with and momentarily amplified the moon's weak magnetic field. Any rocks in the region could have recorded signs of the heightened magnetism before the field quickly died away.
This combination of events could explain the presence of highly magnetic rocks detected in a region near the south pole, on the moon's far side. As it happens, one of the largest impact basins -- the Imbrium basin -- is located in the exact opposite spot on the near side of the moon. The researchers suspect that whatever made that impact likely released the cloud of plasma that kicked off the scenario in their simulations.
"There are large parts of lunar magnetism that are still unexplained," says lead author Isaac Narrett, a graduate student in the MIT Department of Earth, Atmospheric and Planetary Sciences (EAPS). "But the majority of the strong magnetic fields that are measured by orbiting spacecraft can be explained by this process -- especially on the far side of the moon."

Narrett's co-authors include Rona Oran and Benjamin Weiss at MIT, along with Katarina Miljkovic at Curtin University, Yuxi Chen and Gábor Tóth at the University of Michigan at Ann Arbor, and Elias Mansbach PhD '24 at Cambridge University. Nuno Loureiro, professor of nuclear science and engineering at MIT, also contributed insights and advice.

Beyond the sun

Scientists have known for decades that the moon holds remnants of a strong magnetic field. Samples from the surface of the moon, returned by astronauts on NASA's Apollo missions of the 1960s and 70s, as well as global measurements of the moon taken remotely by orbiting spacecraft, show signs of remnant magnetism in surface rocks, especially on the far side of the moon.

The typical explanation for surface magnetism is a global magnetic field, generated by an internal "dynamo," or a core of molten, churning material. The Earth today generates a magnetic field through a dynamo process, and it's thought that the moon once may have done the same, though its much smaller core would have produced a much weaker magnetic field that may not explain the highly magnetized rocks observed, particularly on the moon's far side.

An alternative hypothesis that scientists have tested from time to time involves a giant impact that generated plasma, which in turn amplified any weak magnetic field. In 2020, Oran and Weiss tested this hypothesis with simulations of a giant impact on the moon, in combination with the solar-generated magnetic field, which is weak as it stretches out to the Earth and moon.

In simulations, they tested whether an impact to the moon could amplify such a solar field, enough to explain the highly magnetic measurements of surface rocks. It turned out that it wasn't, and their results seemed to rule out plasma-induced impacts as playing a role in the moon's missing magnetism.

A spike and a jitter

But in their new study, the researchers took a different tack. Instead of accounting for the sun's magnetic field, they assumed that the moon once hosted a dynamo that produced a magnetic field of its own, albeit a weak one. Given the size of its core, they estimated that such a field would have been about 1 micro-Tesla, or 50 times weaker than the Earth's field today.

From this starting point, the researchers simulated a large impact to the moon's surface, similar to what would have created the Imbrium basin, on the moon's near side. Using impact simulations from Katarina Miljkovic, the team then simulated the cloud of plasma that such an impact would have generated as the force of the impact vaporized the surface material. They adapted a second code, developed by collaborators at the University of Michigan, to simulate how the resulting plasma would flow and interact with the moon's weak magnetic field.

These simulations showed that as a plasma cloud arose from the impact, some of it would have expanded into space, while the rest would stream around the moon and concentrate on the opposite side. There, the plasma would have compressed and briefly amplified the moon's weak magnetic field.

This entire process, from the moment the magnetic field was amplified to the time that it decays back to baseline, would have been incredibly fast -- somewhere around 40 minutes, Narrett says.

Would this brief window have been enough for surrounding rocks to record the momentary magnetic spike? The researchers say, yes, with some help from another, impact-related effect.

They found that an Imbrium-scale impact would have sent a pressure wave through the moon, similar to a seismic shock. These waves would have converged to the other side, where the shock would have "jittered" the surrounding rocks, briefly unsettling the rocks' electrons -- the subatomic particles that naturally orient their spins to any external magnetic field. The researchers suspect the rocks were shocked just as the impact's plasma amplified the moon's magnetic field. As the rocks' electrons settled back, they assumed a new orientation, in line with the momentary high magnetic field.

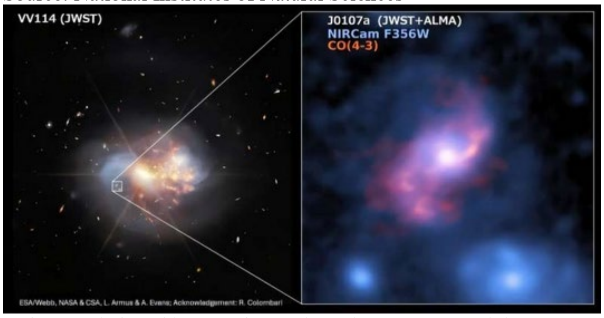
"It's as if you throw a 52-card deck in the air, in a magnetic field, and each card has a compass needle," Weiss says. "When the cards settle back to the ground, they do so in a new orientation. That's essentially the magnetization process."

The researchers say this combination of a dynamo plus a large impact, coupled with the impact's shockwave, is enough to explain the moon's highly magnetized surface rocks -- particularly on the far side. One way to know for sure is to directly sample the rocks for

signs of shock, and high magnetism. This could be a possibility, as the rocks lie on the far side, near the lunar south pole, where missions such as NASA's Artemis program plan to explore.
"For several decades, there's been sort of a conundrum over the moon's magnetism -- is it from impacts or is it from a dynamo?" Oran says. "And here we're saying, it's a little bit of both. And it's a testable hypothesis, which is nice."
The team's simulations were carried out using the MIT SuperCloud. This research was supported, in part, by NASA.

❖ ALMA measures evolution of monster barred spiral galaxy

Date: May 22, 2025
Source: National Institutes of Natural Sciences

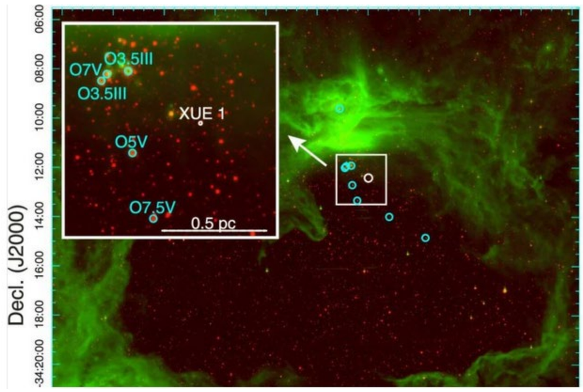


Left: Near-infrared image of a nearby galaxy VV114 and the background monster barred spiral galaxy J0107a at z=2.433 captured by the James Webb Space Telescope. Credit: NASA. Right: Stellar and molecular gas distribution of J0107a. Credit: NASA, ALMA(ESO/NAOJ/NRAO), Huang et al

Astronomers have observed a massive and extremely active barred spiral galaxy in the early Universe and found that it has important similarities and differences with modern galaxies. This improves our understanding of how barred spiral galaxies, like our own Milky Way Galaxy, grow and evolve.
Some spiral galaxies, including the Milky Way, exhibit a straight bar inside the spiral pattern. This bar structure helps channel gas towards the centre of the galaxy where it can be used to form new stars. But why bars form in only about half of spiral galaxies, and how they influence the evolution of the galaxy are unanswered questions.
To study the evolution of spiral galaxies in the early Universe, researchers led by Shuo Huang, a project researcher at the National Astronomical Observatory of Japan and Nagoya University, used the Atacama Large Millimetre/submillimetre Array (ALMA) radio telescope to observe a massive barred spiral galaxy known as J0107a that existed 11.1 billion years ago. Located in the constellation Cetus, J0107a is a "monster" galaxy, meaning a galaxy growing rapidly in the early Universe by forming many new stars. Because they are located far away, it has been difficult to see the detailed structure of monster galaxies and determine what is driving this vigorous star formation. Recently the improved resolution provided by the James Webb Space Telescope has revealed spirals and even bars in some of the monster galaxies. J0107a is the earliest and most massive barred spiral galaxy known to date, so it is the best target for studying the evolution of barred spiral galaxies in the early Universe.
The team found that in J0107a the distribution and motion of gas in the bar is similar to modern galaxies. But compared to modern galaxies, the concentrations of gas are several times higher and the speed of the gas flow is faster, reaching several hundred kilometres per second. Astronomers believe that this massive influx of gas to the centre will fuel signification additional star formation, helping to drive the evolution of this monster galaxy. This is the first time these features have been observed, and they were not predicted by theoretical or simulation models.
Huang comments, "We expect that the detailed information about the distribution and movement of gas gained through these observations will provide important clues for exploring not only the origins of the diversity of galaxies, but also the formation and evolution of more normal barred spiral galaxies."

❖ Unveiling the secrets of planet formation in environments of high UV radiation

Date: May 21, 2025
Source: Penn State



Composite image of the CS 61 bubble in the NGC 6357 star-forming region. Cr

The fundamental building blocks for planet formation can exist even in environments with extreme ultraviolet radiation, according to a new study by an international collaboration led by Penn State astronomers. The study leveraged the unparalleled capabilities of NASA's James Webb Space Telescope (JWST) and sophisticated thermochemical modelling to investigate a protoplanetary disk -- the dust and gas surrounding a new star that can eventually give rise to planets and other celestial bodies -- in one of the most extreme environments in the galaxy.

A paper describing the study appeared May 20 in *The Astrophysical Journal*.

"Astronomers have long sought to understand how planets form within the swirling disks of gas and dust that encircle young stars," said Bayron Portilla-Revelo, a postdoctoral researcher in astronomy and astrophysics in the Eberly College of Science at Penn State and lead author of the study. "These structures -- referred to as protoplanetary disks -- are the birthplaces of extrasolar systems, like our own solar system, which formed 4.5 billion years ago. Protoplanetary disks often form in proximity to massive stars that emit substantial amounts of ultraviolet (UV) radiation, potentially disrupting the disks and affecting their capability to form planets. While significant progress has been made by studying protoplanetary disks in nearby star-forming regions, these regions lack the intense UV radiation present in more massive and common stellar nurseries."

UV radiation refers to non-visible light with more energy than visible light. On Earth, this can damage cells, ranging from a mild sunburn to skin cancer. In space, without a planet's atmospheric filters, UV radiation is far more intense. The focus of the study was a young, solar-mass star known as XUE 1, located approximately 5,500 light-years away from our sun, within a region called the Lobster Nebula, also known as NGC 6357. This region is renowned for harbouring over 20 massive stars, two of which are among the most massive known in our galaxy and are extreme UV emitters. In the same region, the team observed a dozen lower-mass young stars with protoplanetary disks subjected to intense ultraviolet radiation.

Combining JWST observations with sophisticated astrochemical models, the researchers identified the composition of tiny dust grains in the protoplanetary disk around XUE 1 that will eventually grow to form rocky planets. They found that the disk contains sufficient solid material to potentially form at least 10 planets, each with a mass comparable to that of Mercury. The authors also determined the spatial distribution in the disk of a variety of previously detected molecules, including water vapor, carbon monoxide, carbon dioxide, hydrogen cyanide and acetylene.

"These molecules are expected to contribute to the formation of the atmospheres of emerging planets," said Konstantin Getman, research professor in the Department of Astronomy and Astrophysics at Penn State and co-author of the study. "The detection of such reservoirs of dust and gas suggests that the fundamental building blocks for planet formation can exist even in environments with extreme ultraviolet radiation."

Moreover, based on the absence of certain molecules that serve as tracers of UV irradiation in the light detected by JWST, the team inferred that the protoplanetary disk is compact and devoid of gas in its outskirts. It extends only about 10 astronomical units -- a measure based on the average distance between the Earth and sun -- from the host star, roughly the distance from the sun to Saturn. This compactness is likely a result of the external UV radiation eroding the outer regions of the disk, according to the research team.

"These findings support the idea that planets form around stars even when the natal disk is exposed to strong external radiation," said Eric Feigelson, distinguished senior scholar and professor of astronomy and astrophysics and of statistics at Penn State. "This helps explain why astronomers are finding that planetary systems are very common around other stars."

The study of XUE 1 represents a pivotal step in understanding the impact of external radiation on protoplanetary disks, the researchers said. It lays the groundwork for future observational campaigns with both space- and ground-based telescopes aimed at building a more comprehensive picture of planet formation across different cosmic environments. This research underscores the transformative capabilities of NASA's James Webb satellite observatory in probing the intricacies of planet formation and highlights the resilience of protoplanetary disks in the face of formidable environmental challenges, according to Portilla-Revelo.

In addition to Portilla-Revelo, Getman and Feigelson, the research team includes Maria Claudia Ramírez-Tannus and Thomas Henning at the Max-Planck Institut für

Astronomie in Heidelberg, Germany; Thomas J. Haworth at Queen Mary University of London; Rens Waters at Radboud University and SRON Netherlands Institute for Space Research in the Netherlands; Arjan Bik and Jenny Frediani at Stockholm University in Sweden; Inga Kamp at University of Groningen in the Netherlands; Sierk E. van Terwisga at the Austrian Academy of Sciences; Andrew J. Winter at the Université Côte d'Azur in Nice, France, and the Max-Planck Institut für Astronomie in Heidelberg, Germany; Veronica Roccatagliata at the Universitàdi Bologna and INAF-Osservatorio Astrofisico di Arcetri in Italy; Thomas Preibisch at Ludwig-Maximilians-Universität in Germany; Elena Sabbi at the Gemini Observatory in Tucson, Arizona; Peter Zeidler at the Space Telescope Science Institute in Baltimore, Maryland; and Michael A. Kuhn at the University of Hertfordshire in the United Kingdom.

NASA funded the research, with additional support from the Centre for Exoplanets and Habitable Worlds at Penn State, the Deutsche Forschungsgemeinschaft, the international Gemini Observatory -- a program of NSF NOIRLab, which is managed by the Association of Universities for Research in Astronomy under a cooperative agreement with the U.S. National Science Foundation, the Royal Society Dorothy Hodgkin Fellowship and UKRI guaranteed funding for a Horizon Europe ERC consolidator grant, the Swedish National Space Agency, the German Aerospace Centre, the German Federal Ministry for Economic Affairs and Energy, the European Union's Horizon 2020 research and innovation program, and the European Research Council via the ERC Synergy Grant "ECOGAL."

- Gas location drives star formation in distant galaxies

Date: May 20, 2025

Source: International Centre for Radio Astronomy Research

The red shade shows the atomic hydrogen gas content of the galaxy overlaid on the optical image. Credit: Legacy Surveys / D. Lang (Perimeter Institute)/ T. Westmeier – ICRAR

Researchers at the International Centre for Radio Astronomy Research (ICRAR) made the discovery about galaxies by studying the gas distribution that helps create stars.

Using CSIRO's ASKAP radio telescope located at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, researchers explored the gas distribution in about 1,000 galaxies as part of the WALLABY survey.

Lead author Seona Lee, a PhD student at The University of Western Australia node of ICRAR, said the findings give new insights into how stars are born from gas.

While earlier surveys could only map the gas distribution in a few hundred galaxies, the WALLABY survey has successfully mapped the atomic hydrogen gas in a significantly larger sample of galaxies.

The survey revealed that having more gas in a galaxy does not automatically mean it will create more stars. Instead, galaxies that are forming stars usually have a higher concentration of gas in the areas where the stars reside.

"It was very exciting to see a correlation between star formation and where the atomic hydrogen gas is located," Ms Lee said.

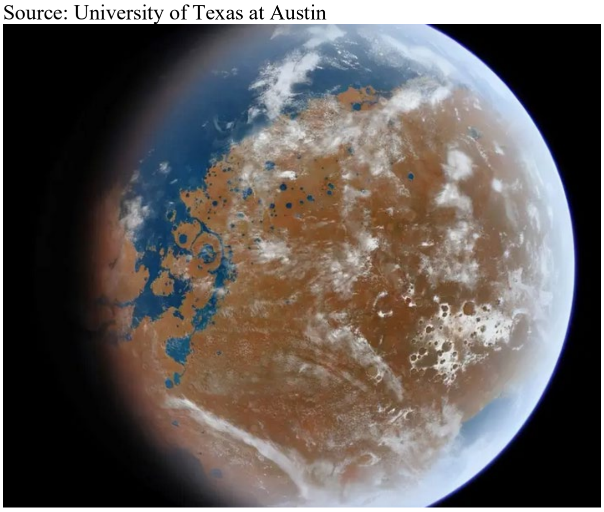
Higher-resolution observations from telescopes like ASKAP, owned and operated by CSIRO, Australia's national science agency, allowed Ms Lee to measure the location and density of the atomic gas for an unprecedented number of galaxies.

Senior Principal Research Fellow at ICRAR Professor Barbara Catinella, who co-leads the WALLABY survey, said atomic hydrogen gas

is the essential ingredient for making stars, in the same way that flour is to a cake.
"While different cakes require different amounts of flour, to bake a cake properly, you focus on the flour that's in the bowl, not the unused flour left in the package," Professor Catinella said.
"Similarly, understanding how stars are formed requires us to measure the atomic gas where stars are actually forming, rather than considering the total gas content, which includes the unused gas in the outer regions."
The research showed that being able to conduct more detailed radio observations is key to helping scientists understand how galaxies grow and change over time. The team looked at radio waves and visible light from nearby galaxies to determine the amount of gas in the parts of the galaxy where stars are being born.
"To learn about how stars are formed, we had to measure the atomic hydrogen gas in areas where stars are actively coming to life," Ms Lee said.
"This is important for figuring out just how much gas is really supporting the creation of new stars."

- ❖ Missing link in early Martian water cycle discovered

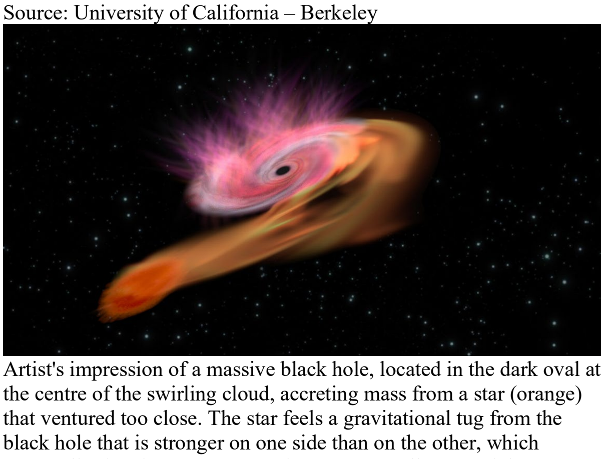
Date: May 20, 2025
Source: University of Texas at Austin



Billions of years ago, water flowed on the surface of Mars. But scientists have an incomplete picture of how the Red Planet's water cycle worked.
That could soon change after two graduate students at The University of Texas at Austin filled a large gap in knowledge about Mars' water cycle -- specifically, the part between surface water and groundwater.
Students Mohammad Afzal Shadab and Eric Hiatt developed a computer model that calculates how long it took for water on early Mars to percolate from the surface down to the aquifer, which is thought to have been about a mile underground. They found that it took anywhere from 50 to 200 years. On Earth, where the water table in most places is much closer to the surface, the same process typically takes just a few days.
The results were published in the journal *Geophysical Research Letters*.
The researchers also determined that the amount of water trickling between surface and aquifer could have been enough to cover Mars with at least 300 feet of water. This was potentially a significant portion of the planet's total available water.
The research helps complete scientists' understanding of the water cycle on early Mars, said Shadab, who earned his doctoral degree from UT Austin and is now a postdoctoral researcher at Princeton University. This new understanding will be useful in determining how much water was available to evaporate and fill lakes and oceans with rain, and ultimately, where the water ended up.
"We want to implement this into [an integrated model] of how the water and land evolved together over millions of years to the present state," said Shadab, who was the study's lead author. "That will bring us very close to answering what happened to the water on Mars."
Today, Mars is largely dry, at least at the surface. But 3 to 4 billion years ago -- at around the time that life was getting started on Earth -- oceans, lakes and rivers carved valleys through Mars' mountains and craters and imprinted shorelines in the rocky surface. Ultimately, Mars' water took a different path than Earth's. Most of it is now either locked in the crust or was lost to space along with Mars' atmosphere. Understanding how much water was available near the surface could help scientists determine whether it was in the right places long enough to create the chemical ingredients needed for life.
The new findings add to an alternative picture of early Mars in which there was little water going back into the atmosphere through evaporation and raining down to refill oceans, lakes and rivers -- as it would have on Earth -- said coauthor Hiatt, who recently graduated with a doctoral degree from UT Jackson School of Geosciences.
"The way I think about early Mars is that any surface water you had -- any oceans or large

standing lakes -- were very ephemeral," he said. "Once water got into the ground on Mars, it was as good as gone. That water was never coming back out."
The researchers said that the findings are not all bad news for potential life on Mars. If nothing else, the water seeping into the crust wasn't being lost to space, Hiatt said. That knowledge could one day be important for future explorers looking for buried water resources to sustain a settlement on the Red Planet.
Shadab and Hiatt's research was supported by a Blue Sky grant from the University of Texas Institute for Geophysics, a research unit of the Jackson School, and grants from UT Austin's Centre for Planetary Systems Habitability and NASA.
The work was conducted while Shadab was earning a doctoral degree from the Oden Institute for Computational Engineering and Sciences at UT Austin. Other coauthors include Rickbir Bahia and Eleni Bohacek from the European Space Agency (now at UK Space Agency), Vilmos Steinmann from the Eotvos Lorand University in Hungary, and Professor Marc Hesse from the Jackson School's Department of Earth and Planetary Sciences at UT Austin.

- Not one, but two massive black holes are eating away at this galaxy

Astronomers found a stealth black hole roaming in this galaxy, far from the massive black hole in the galaxy's core
Date: May 19, 2025
Source: University of California – Berkeley

Artist's impression of a massive black hole, located in the dark oval at the centre of the swirling cloud, accreting mass from a star (orange) that ventured too close. The star feels a gravitational tug from the black hole that is stronger on one side than on the other, which eventually rips the star apart. In the process, stellar material starts flowing onto the black hole, part of which is captured and the rest ejected, producing a sudden boost in luminosity, especially in X-rays.
Astronomers have discovered nearly 100 examples of massive black holes shredding and devouring stars, almost all of them where you'd expect to find massive black holes: in the star-dense cores of massive galaxies.
University of California, Berkeley, astronomers have now discovered the first instance of a massive black hole tearing apart a star thousands of light years from the galaxy's core, which itself contains a massive black hole.
The off-centre black hole, which has a mass about 1 million times that of the sun, was hiding in the outer regions of the galaxy's central bulge, but revealed itself through bursts of light generated by the spaghettification of the star -- a so-called tidal disruption event, or TDE. In a TDE, the immense gravity of a black hole tugs on a star -- similar to the way the moon raises ocean tides on Earth, but a lot more violently.
"The classic location where you expect massive black holes to be in a galaxy is in the centre, like our Sag A* at the centre of the Milky Way," said Yuhan Yao, a Miller Postdoctoral Fellow at UC Berkeley who is lead author of a paper about the discovery recently accepted for publication in *The Astrophysical Journal Letters (ApJL)*. "That's where people normally search for tidal disruption events. But this one, it's not at the centre. It's actually about 2,600 light years away. That's the first optically discovered off-nuclear TDE discovered."
The galaxy's central massive black hole, about 100 million times the mass of our sun, is also gorging itself, but on gas that has gotten too close to escape.
Studies of massive black holes at galactic centres tell astronomers about the evolution of galaxies like our own, which has one central black hole -- called SagA* because of its location within the constellation Sagittarius -- weighing in at a puny 4 million solar masses. Some of the largest galaxies have central black holes weighing several 100 billion solar masses, presumably the result of the merger of many smaller black holes.
Finding two massive black holes in the centre of a galaxy is not surprising. Most large galaxies are thought to have massive black holes in their cores, and since galaxies often collide and merge as they move through space, large galaxies should occasionally harbour more than one supermassive black hole -- at least until they collide and merge into an even bigger black hole. They typically hide in stealth mode until they reveal their presence by grabbing nearby stars or gas clouds, creating a short-lived burst of light. These are rare events, however. Astronomers

calculate that a massive black hole would encounter a star once every 30,000 years, on average.

The new TDE, dubbed AT2024tvd, was detected by the Zwicky Transient Facility, an optical camera mounted on a telescope at Palomar Observatory near San Diego, and confirmed by observations with radio, X-ray and other optical telescopes, including NASA's Hubble Space Telescope.

"Massive black holes are always at the centres of galaxies, but we know that galaxies merge -- that is how galaxies grow. And when you have two galaxies that come together and become one, you have multiple black holes," said co-author Ryan Chornock, a UC Berkeley associate adjunct professor of astronomy. "Now, what happens? We expect they eventually come together, but theorists have predicted that there should be a population of black holes that are roaming around inside galaxies."

The discovery of one such roaming black hole shows that systematic searches for the signature of a TDE could turn up more rogue black holes. The find also validates plans for a space mission called LISA -- the Laser Interferometer Space Antenna -- that will look for gravitational waves from mergers of massive black holes like these.

"This is the first time that we actually see massive black holes being so close using TDEs," said co-author Raffaella Margutti, a UC Berkeley associate professor of astronomy and of physics. "If these are a couple of supermassive black holes that are getting closer together -- which is not necessarily true -- but if they are, they might merge and emit gravitational waves that we'll see in the future with LISA."

LISA will complement ground-based gravitational wave detectors, such as LIGO and Virgo, which are sensitive to the merger of black holes or neutron stars weighing less than a few hundred times the mass of our sun, and telescopic studies of pulsar flashes, such as the Nanograv pulsar timing array experiment, which are sensitive to gravitational waves from the mergers of supermassive black holes weighing billions of solar masses. LISA's sweet spot is black holes of several million solar masses. LISA is slated to be launched in the next decade.

Transient outbursts

Because black holes are invisible, scientists can only find them by detecting the light produced when they shred stars or gas clouds and create a bright, hot, rotating disk of material that gradually falls inward. TDEs are powerful probes of black hole accretion physics, Chornock said, revealing how close material can get to the black hole before being captured and the conditions necessary for black holes to launch powerful jets and winds.

The most productive search for TDEs has used data from the Zwicky Transient Facility, originally built to detect supernova explosions, but also sensitive to other flashes in the sky.

The ZTF has discovered nearly 100 TDEs since 2018, all within the cores of galaxies. X-ray satellites have also detected a few TDEs, including two in the outskirts of a galaxy that also has a central black hole. In those galaxies, however, the black holes are too far apart to ever merge. The newly discovered black hole is close enough to the core's massive black hole to potentially fall toward it and merge, though not for billions of years.

Yao noted that two alternative scenarios could explain the presence of the wandering black hole in AT2024tvd. It could be from the core of a small galaxy that merged with the larger galaxy long ago and is either moving through the larger galaxy on its way out or has become bound to the galaxy in an orbit that may, eventually, bring it close enough to merge with the black hole at the core.

Erica Hammerstein, another UC Berkeley postdoctoral researcher, scrutinized the Hubble images as part of the study, but was unable to find evidence of a past galaxy merger.

AT2024tvd could also be a former member of a triplet of black holes that used to be at the galactic core. Because of the chaotic nature of three-body orbits, one would have been kicked out of the core to wander around the galaxy.

Searching galaxies for off-centre black holes

Because the ZTF detects hundreds of flashes of light around the northern sky each year, TDE searches to date have focused on flashes discovered near the cores of galaxies, Yao said. She and Chornock created an algorithm to distinguish between the light produced by a supernova and a TDE, and employed it to search through the 10,000 or so detections by ZTF to date to find bursts of light in the galactic centre that fit the characteristics of a TDE.

"Supernovae cool down after they peak, and their colour becomes redder," Yao said. "TDEs remain hot for months or years and have consistently blue colours throughout their evolution."

TDEs also exhibit broad emission lines of hydrogen, helium, carbon, nitrogen and silicon.

Last August, the Berkeley team discovered a burp of light that looked like a TDE, but its location seemed off-centre, though within the resolution limits of the ZTF. The researchers suspected the black hole was indeed off centre, and immediately requested time on several telescopes to pinpoint its location. These included NASA's Chandra X-ray Observatory, the Very Large Array and the Hubble Space Telescope. They all confirmed its off-nucleus location, with HST providing a distance of about 2,600 light years -- about one-tenth the distance between our sun and Sag A*.

Though close to the central black hole, the off-nuclear black hole is not gravitationally bound to it. Because the black hole at the core spews out energy as it accretes infalling gas, it is categorized as an active galactic nucleus.

Yao and her team hope to find other roaming TDEs, which will give astronomers an idea of how often galaxies and their core black holes merge, and thus how long it takes to form some of the extreme, supermassive black holes.

"AT2024tvd is the first offset TDE captured by optical sky surveys, and it opens up the entire possibility of uncovering this elusive population of wandering black holes with future sky surveys," Yao said. "Right now, theorists haven't given much attention to offset TDEs. They primarily predict rates for TDEs occurring at the centres of galaxies. I think this discovery really motivates them to compute rates for offset TDEs, as well."

The 34 co-authors who contributed to the paper come from institutions in the United States, United Kingdom, Sweden, Russia, Germany, Australia and the Netherlands. ZTF is a public-private partnership, with equal support from the ZTF Partnership and the U.S. National Science Foundation.

- Streaked slopes on Mars probably not signs of water flow, study finds

Date: May 19, 2025
Source: Brown University

CaSSIS camera aboard ESA's ExoMars Trace Gas Orbiter captures dark finger-like slope streaks extending across Mars' dusty surface in Arabia Terra. New research by Bickel and Valantinas reveals these features form through dry avalanches triggered by wind and impacts rather than liquid water. These active geological phenomena may transport millions of tons of dust annually, potentially playing a significant role in Mars' climate system. Credit: NASA

A new study by planetary scientists at Brown University and the University of Bern in Switzerland casts doubt on one of the most tantalizing clues that water might be flowing on present-day Mars.

For years, scientists have spied strange streaks running down Martian cliffsides and crater walls. Some have interpreted those streaks as liquid flows, suggesting the possibility of currently habitable environments on the Red Planet. But this new study, which used machine learning to create and analyse a massive dataset of slope streak features, points to a different explanation: dry process related to wind and dust activity.

"A big focus of Mars research is understanding modern-day processes on Mars -- including the possibility of liquid water on the surface," said Adomas Valantinas, a postdoctoral researcher at Brown who coauthored the research with Valentin Bickel, a researcher at Bern. "Our study reviewed these features but found no evidence of water. Our model Favors dry formation processes."

The research was published in *Nature Communications* on Monday, May 19.

Scientists first saw the odd streaks in images returned from NASA's Viking mission in the 1970s. The sinewy features are generally darker in hue than the surrounding terrain and extend for hundreds of meters down sloped terrain. Some last for years or decades, while others come and go more quickly. The shorter-lived features -- dubbed recurring slope linear (RSL) -- seem to show up in the same locations during the warmest periods of the Martian year.

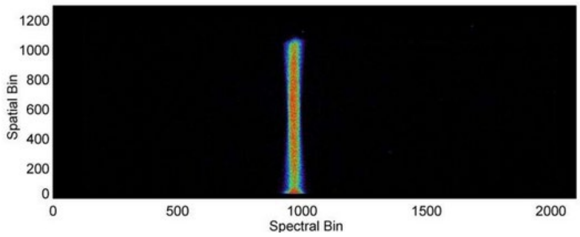
The origin of the streaks has been a hot topic among planetary scientists. Modern Mars is remarkably dry, and temperatures rarely peak above freezing. Still, it's possible that small

amounts of water -- perhaps sourced from buried ice, subsurface aquifers or abnormally humid air -- could mix with enough salt to create a flow even on the frozen Martian surface. If true, RSLs and slope streaks could mark rare, habitable niches on a desert world.
Other researchers haven't been convinced. They contend the streaks are triggered by dry processes like rock falls or wind gusts, and only appear liquid-like in orbital images.
Hoping for new insights, Bickel and Valantinas turned to a machine learning algorithm to catalogue as many slope streaks as they could. After training their algorithm on confirmed slope streak sightings, they used it to scan more than 86,000 high-resolution satellite images. The result was a first-of-its-kind global Martian map of slope streaks containing more than 500,000 streak features.
"Once we had this global map, we could compare it to databases and catalogues of other things like temperature, wind speed, hydration, rock slide activity and other factors." Bickel said. "Then we could look for correlations over hundreds of thousands of cases to better understand the conditions under which these features form."
This geostatistical analysis showed that slope streaks and RSLs are not generally associated with factors that suggest a liquid or frost origin, such as a specific slope orientation, high surface temperature fluctuations or high humidity. Instead, the study found that both features are more likely to form in places with above average wind speed and dust deposition -- factors that point to a dry origin.
The researchers conclude that the streaks most likely form when layers of fine dust suddenly slide off steep slopes. The specific triggers may vary. Slope streaks appear more common near recent impact craters, where shockwaves might shake loose surface dust. RSLs, meanwhile, are more often found in places where dust devils or rockfalls are frequent.
Taken together, the results cast new doubt on slope streaks and RSLs as habitable environments.
That has significant implications for future Mars exploration. While habitable environments might sound like good exploration targets, NASA would rather keep its distance. Any Earthly microbes that may have hitched a ride on a spacecraft could contaminate habitable Martian environments, complicating the search for Mars-based life.
This study suggests that the contamination risk at slope streak sites isn't much of a concern.
"That's the advantage of this big data approach," Valantinas said. "It helps us to rule out some hypotheses from orbit before we send spacecraft to explore."

- ❖ Ultraviolet data from NASA's Europa Clipper mission

Europa-UVS completes commissioning despite Earthside challenges

Date: May 15, 2025
Source: Southwest Research Institute



The Southwest Research Institute-led Ultraviolet Spectrograph (UVS) aboard NASA's Europa Clipper spacecraft has successfully completed its initial commissioning following the October 14, 2024, launch. Scheduled to arrive in the Jovian system in 2030, the spacecraft will orbit Jupiter and ultimately perform repeated close flybys of the icy moon Europa. Previous observations show strong evidence for a subsurface ocean of liquid water that could host conditions favourable for life.

Europa-UVS is one of nine science instruments in the mission payload, including another SwRI-led and developed instrument, the MAss Spectrometer for Planetary EXploration (MASPEX). The UVS instrument collects ultraviolet light to create images to help determine the composition of Europa's atmospheric gases and surface materials.
"SwRI scientists started this process in January from NASA's Jet Propulsion Laboratory, however, we had to evacuate due to the fires in southern California," said SwRI Institute Scientist Dr. Kurt Retherford, principal investigator (PI) of Europa-UVS. "We had to wait until May to open the instrument's aperture door and collect UV light from space for the first time. We observed a part of the sky, verifying that the instrument is performing well."
SwRI has provided ultraviolet spectrographs for other spacecraft, including ESA's Rosetta comet orbiter, as well as NASA's New Horizons mission to Pluto, Lunar Reconnaissance Orbiter mission in orbit around the Moon and Juno mission to Jupiter.
"Europa-UVS is the sixth in this series, and it benefits greatly from the design experience gained by our team from the Juno-UVS instrument, launched in 2011, as it pertains to operating in Jupiter's harsh radiation

environment," said Matthew Freeman, project manager for Europa-UVS and director of SwRI's Space Instrumentation Department. "Each successive instrument we build is more capable than its predecessor."

Weighing just over 40 pounds (19 kg) and drawing only 7.9 watts of power, UVS is smaller than a microwave oven, yet this powerful instrument will determine the relative concentrations of various elements and molecules in the atmosphere of Europa once in the Jovian system. A similar instrument launched in 2023 aboard ESA's Jupiter Icy Moons Explorer spacecraft, which will be studying several of Jupiter's icy moons, gases from the volcanic moon Io and Jupiter itself. Having two UVS instruments in the Jupiter system at one time offers complementary science.

In addition to performing atmospheric studies, Europa-UVS will also search for evidence of potential plumes erupting from within Europa. "Europa-UVS will hunt down potential plumes spouting from Europa's icy surface and study them to understand what they tell us about the nature of subsurface water reservoirs," said Dr. Thomas Greathouse, SwRI staff scientist and Europa-UVS co-deputy PI. "The instrument is working fabulously, and we're excited about its ability to make new discoveries once we get to Jupiter."

NASA's Jet Propulsion Laboratory (JPL) manages the Europa Clipper mission for NASA's Science Mission Directorate in Washington, D.C. The Europa Clipper mission was developed in partnership with the Johns Hopkins University Applied Physics Laboratory (APL), in Laurel, Maryland.